

# NAVAL POSTGRADUATE SCHOOL Monterey, California



## THE RECRUITING STATION LOCATION EVALUATION SYSTEM (RSLES): A SUMMARY REPORT

by

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June 9, 2000

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Prepared for: Directorate for Accession Policy,  
Office of the Assistant Secretary of Defense (FMP),  
Deputy Assistant Secretary of Defense (MPP)  
Room 2B271  
4000 Defense Pentagon  
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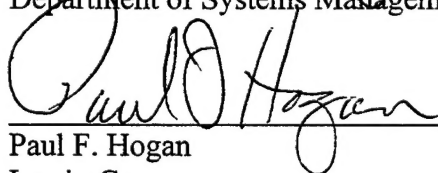
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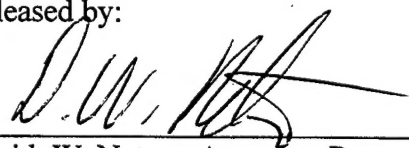
  
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<b>REPORT DOCUMENTATION PAGE</b>			<b>Form Approved</b>	
<b>OMB No 0704-0188</b>				
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE June 9, 2000		3. REPORT TYPE AND DATES COVERED Technical Report
4. TITLE AND SUBTITLE The Recruiting Station Location Evaluation System (RSLES): A Summary Report			5. FUNDING MIPR #97APAD0058	
6. AUTHOR(S)  Stephen Mehay Kevin Gue Paul Hogan				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Department of Systems Management Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER  NPS-SM-00-009	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Directorate for Accession Policy Office of the Assistant Secretary of Defense (FMP) Deputy Assistant Secretary of Defense (MPP) Room 2B271 4000 Defense Pentagon Washington, D.C. 20301-4000			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release. Distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words.) The Department of Defense and the Joint Recruiting Facilities Committee oversee the operation and maintenance of recruiting facilities for the Service recruiting commands. DOD is concerned with identifying the most cost-effective geographic locations for the Services' recruiting offices. This report provides an overview of the Recruiting Station Location Project undertaken for the Assistant Secretary of Defense (FMP), Office of Accession Policy. The project developed models to assess the costs and benefits of alternative geographic locations for recruiting offices. The model is contained in the Recruiting Station Location Evaluation System (RSLES), which combines extensive ZIP code level data bases with an optimization routine and a geographic mapping capability. RSLES chooses optimal geographic locations for recruiting offices by balancing the impact of pre-specified ZIP code locations on costs and on new contract production. The report summarizes the components of the RSLES system. These include: the data bases of ZIP code level contracts and other demographic attributes; boundary files for all U.S. ZIP codes and ZIP code address of recruiting offices; econometric cost and contract production models; and, the optimization and mapping software. The report also details the architecture of the RSLES system and the integrating shell. Finally, the report describes efforts to apply and validate the RSLES system using data on Navy stationing actions in FY99 and FY00. The applications identify significant improvements in production that could be achieved by application of the RLSES model.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 27	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT SAR	

## ABSTRACT

The Department of Defense and the Joint Recruiting Facilities Committee oversee the operation and maintenance of recruiting facilities for the Service recruiting commands. DOD is concerned with identifying the most cost-effective geographic locations for the Services' recruiting offices. This report provides an overview of the Recruiting Station Location Project undertaken for the Assistant Secretary of Defense (FMP), Office of Accession Policy. The project developed models to assess the costs and benefits of alternative geographic locations for recruiting offices. The model is contained in the Recruiting Station Location Evaluation System (RSLES), which combines extensive ZIP code level data bases with an optimization routine and a geographic mapping capability. RSLES chooses optimal geographic locations for recruiting offices by balancing the impact of pre-specified ZIP code locations on costs and on new contract production. The report summarizes the components of the RSLES system. These include: the data bases of ZIP code level contracts and other demographic attributes; boundary files for all U.S. ZIP codes and ZIP code address of recruiting offices; econometric cost and contract production models; and, the optimization and mapping software. The report also details the architecture of the RSLES system and the integrating shell. Finally, the report describes efforts to apply and validate the RSLES system using data on Navy stationing actions in FY99 and FY00. The applications identify significant improvements in production that could be achieved by application of the RLSES model.

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# **Recruiting Station Location Evaluation System (RSLES)**

## **I. Background and Project Overview**

The Accession Policy Directorate of the Office of the Assistant Secretary of Defense (Force Management Policy) is responsible for policy development and oversight of the DoD Recruiting Facilities Program (RFP), which is designed to provide facilities for recruitment of young people into the U.S. Military. A vital part of Accession Policy's mission is oversight of the Military Services' short-term and long-term recruiting facilities requirements. AP is assisted in this task by the Joint Recruiting Facilities Committee (JRFC), which provides policy guidance and broad management of the annual RFP and approves or disapproves Service requests to open, close, expand or relocate offices. In addition, the Army Corps of Engineers plans, budgets, and executes the annual RFP and manages those facilities that require commercial leases.

The overall goal of the RFP is to acquire and maintain the number of recruiting offices necessary to meet the Service's recruiting mission and to do so at minimum cost. With the cost minimization goal in mind the JRFC attempts to collocate multiple Services in each recruiting office where possible. Balancing costs and production creates numerous policy tradeoffs that JRFC decision makers must confront, often with scant objective data or models for guidance.

Management of the recruiting facilities program requires knowledge of the recruitment impact of various demographic characteristics of local communities where facilities are to be located. For example, contract production is affected by the following factors: (a) the size, propensity and quality of the local youth population; (b) civilian youth unemployment; (c) recruiting resources (e.g., recruiters, advertising, etc.); and (d) the characteristics of the recruiting station itself (size, collocation, and especially location). The JRFC and the Services need objective data and models to help determine the effect of geographic location on station production and costs.

The National Defense Authorization Act of 1996 requested that DoD study the feasibility of using a joint process among the Armed Forces for determining the location of recruiting stations and to base station location decisions on jointly conducted market research. The existing joint process of station location is limited primarily to coordinating Service recruiting facility requests. A Joint-Service recruiting task force recommended that the DoD conduct analyses to develop a model for measuring efficiency in terms of the impacts of closing, opening, and relocating recruiting stations. To that end, the Naval Postgraduate School was tasked to develop the necessary data, analyses and models.

The project required construction and integration of several separate components of the integrated model. First, it was necessary to construct data for and estimate econometric models to obtain the effects of various determinants on the production of enlistment contracts. Model estimates were used to forecast recruiting station production for each Service based on the characteristics of the local market area. The approach adopted was to estimate a model of high quality contracts by Service in a local geographic area – defined by ZIP code. The explanatory

variables in each model included market characteristics (relative pay, youth population, unemployment, etc), recruiting resources, and station characteristics (station type, proximity to the market and to other stations, for example). Model specification required collection of data on enlistment production, number of recruiters, station proximity to market, market size, youth population, station accessibility, neighborhood quality, recruiter competition, and local or regional economic conditions.

Second, an economic analysis of station costs was required. This task resulted in a station cost estimation model. Specification of the models included the size and configuration of the station, collocation of Services in the station, and local market characteristics (such as population density and per capita income).

Third, optimization techniques were required to evaluate actual and potential recruiting station sites (ZIP codes) and to identify station locations which can provide cost effective delivery of annual accession requirements. The project developed an optimization model using the General Algebraic Modeling System (GAMS). GAMS utilized as inputs the production and station data and the econometric models estimated in steps one and two.

Optimal locations for recruiting stations and assignment of recruiters to these stations consider a recruiting market as a collection of ZIP codes. Each ZIP code produces a number of enlistment contracts that can be determined or predicted from the production model. Given a set of candidate locations for stations, the number of stations to be opened and the available number of recruiters, the decisions are then to select a subset of candidate locations and to assign a fixed number of recruiters to the selected locations. The goal in making these decisions is to maximize the number of enlistment contracts produced within a market territory (such as a metropolitan area), subject to a budget constraint.

The optimization model considers the costs of closing, relocating, and opening recruiting stations and balances these against the market production potential. The effect of competition among the services must be included in the production function. In practice, the size of a station at a candidate location is limited by the nature of the local real estate market. Moreover, there are a number of qualitative factors that make a location suitable for a recruiting station such as its proximity to shopping malls, high schools, and bus or subway stops.

Finally, the project required a Decision Support System to provide access by users to the various data bases and the optimization output. We developed the Recruiting Station Location Evaluation System (RSLES) for application to Service-specific and JRFC-level problems. The optimization software allows the user to answer a variety of questions and station-location scenarios:

- *Station relocation*  
Where should a current site be relocated to increase net productivity?



- *Station closing*  
Which station(s) should be closed?  
Where should the closed station's recruiters be reassigned?  
How should the closed station's territory be reassigned?
- *Station opening*  
Where are productive locations for opening new stations?  
What should the territory for the new station look like?  
What will be the impact on recruiting cost and productivity?  
Where should new recruiters be assigned?

Details of the specific elements of the RLSES optimization model are reviewed below.

**Production Data Base and Production Forecasting Models.** We collected ZIP code-level contract production data for all of the military Services. Army and Navy data were collected for each quarter for the 1995-1997 period, thus providing a large data set to analyze production at the ZIP code and recruiting station (RS) level. We also collected extensive demographic and economic data for counties and, where possible, for ZIP codes, which was added to the production database. Because of our focus on the effect of geographic location, the data collection effort also required data on the ZIP code location of each individual RS, the territory assigned to each RS (i.e., the collection of ZIP codes exclusively covered by the RS's recruiters), and the number of recruiters assigned to each station. Further, we required data on the distances between each ZIP code contained in an RS's territory and the location of the RS itself in order to estimate travel distances of recruiters.

With this information we were able to construct predictive models of contract production for each service and to analyze production effects of the geographic location of stations, interactions between the Navy and the Army recruiters, and collocation of recruiters. The Air Force and Marine Corps models are based on data for 1998 only, whereas the Navy and Army models are based on three years (1995-97) of quarterly data.

**Station Cost Data Base and Forecasting Models.** We collected station lease and other cost information for several years using data provided in the Recruiting Facilities Management Information System (RFMIS) data base. Other ZIP code-level demographic information was added to capture the effects of geographic location factors other than size on station costs. All of these factors were used to build station cost models that predict the annual costs of a station located at a given site (ZIP code). The model takes into account the size of the station (number of recruiters), the geographic location of the station, and whether recruiters from more than one service are collocated in the station and, if so, with how many other services.

**GAMS Optimization Model.** GAMS mathematical programming software, along with CPLEX solver software, were used to program the optimization routines for each selected geographic area. The GAMS set up analyzed a given area, metropolitan area for example, and identified the optimum location of RS's based on predicted contract production and costs. The software allows the user to pre-specify ZIP codes, or sets of ZIP codes, that can be evaluated as candidates for station openings, closing, or relocation. The output identifies station locations,

station size, and station territories. The optimization is based on the geographic set up that maximized production subject to a budget constraint for each service. Alternative optimization routines also were tested. Considerable time was spent developing solvable problems with GAMS and identifying the size of problems that can be solved within the constraints of the software.

**RLSES Decision Support Software.** All of the production and cost data were entered into an Access data base. The Access production and cost data bases, the cost and contract production predicting models, and the GAMS optimization software were integrated in the RSLES software. The interface is programmed in Visual Basic and also integrates MAPINFO software to graphically display the results of the optimization output. The RSLES software allows users to implement alternative station location scenarios and estimate the actual production and cost associated with each scenario.

This report is divided into the following sections. Section II briefly describes the construction of the contract production data base and the facility cost data base. The section also provides an overview of the basic model that is used to predict contract production by ZIP code and the statistical results obtained from the model. This model is a key element of the optimization model (described below in Section IV). An in-depth exposition of the statistical models is presented in a separate technical report (“Enlistment Supply Models at the Local Market Level,” by Paul Hogan, Stephen Mehay, Jared Hughes, and Michael Cook). Section III discusses the construction of the model used to predict station costs and the statistical results of estimating the model. Section IV describes the set up of the GAMS optimization model, which incorporates the production and cost data bases and statistical results. A separate technical report (“GAMS Optimization Model” by Kevin R. Gue) provides an in-depth description of the optimization routines. Section V describes the components of the RSLES decision support software and how the components are integrated in the tool. A more complete discussion is provided in a separate technical report (“Description of RSLES Interface,” by Dale Houck and Mark Shigley). Section VI applies the RSLES software to actual Navy and Army station location decisions. Predicted production for the Services’ location decisions are compared to predicted production under the optimal location decision from RSLES. A separate technical report (“Validation and Application of the RSLES Model,” by Teriann Sammis, Donald Wilkinson, Stephen Mehay, and Kevin Gue) describes the applications and validation procedure in much greater detail. Section VII concludes the report.

## **II. Analysis of Station Location Effects on Production**

### **Description of Contract Production Data Base**

Following prior studies, we attempted to model the supply of male “high quality” enlistments—high school diploma graduates who score in the top half of the Armed Forces Qualifying Test (AFQT). Observed enlistments from this group are assumed to represent true supply behavior, in that these groups are not demand constrained. Supply models are estimated for two separate geographic levels—the ZIP code level and the station (market) level. The analysis initially focuses on the interaction between Army and Navy recruiters.

Army enlistment contract information is taken from the Army's ATAS database, which provides quarterly contracts by ZIP code, from the fourth quarter of fiscal 1994 through fourth quarter of fiscal 1997, a total of thirteen quarters. It also includes ZIP code demographics, including the 17-21 year old population, area in square miles, and the number of high schools. Importantly, it includes the location of the Army station that serves each ZIP code and the number of recruiters assigned to each station. Data on Navy contracts are taken from Navy's STEAM database. It also includes data regarding the number of Navy production recruiters assigned to a recruiting station each quarter, the ZIP codes in that station's territory, as well as the ZIP code in which the recruiting station is located. In addition, data on per capita income and median household income from the 1990 Census are added to the file. These variables are available at the ZIP code level, but only for one year. The county unemployment rate (available in ATAS) is also included in some specifications.

Each data base identifies the number of recruiters assigned to a given recruiting station and all of the ZIP codes contained within the station's exclusive territory. To measure recruiter presence in each ZIP code, we allocated the total number of recruiters assigned to each station to each ZIP code covered by that station based on the ratio of the population of 17-21 year olds in each ZIP code to the total population of 17-21 year olds in the station's market area. We believe that this distribution is preferred to assigning all of the station's recruiters to every ZIP code in its market territory in that it accounts for the competing demand for a recruiter's time across the ZIP codes assigned to a station.

We construct estimated distances from each ZIP code in a station's territory based on the radial distances between the centroid of the ZIP code and the centroid of the ZIP code where the recruiting station is located (centroids are identified by latitude and longitude). For those ZIP codes where the facility is located, the distance is calculated as the radius of a circle with the same area as that of the ZIP code.

Finally, the Army and Navy data identified the ZIP codes that contain each service's recruiting stations. We construct a third variable indicating whether both Army and Navy have a station in a given ZIP code. Given JRFC policies that encourage collocation, especially when service facilities are in close proximity to each other, we interpret this to be a "co-located" or "joint" recruiting station. However, though we do not know with certainty that the services actually share the same physical facility.

### **Army-Navy Joint Contract Production Models**

We pool cross-sections (ZIP codes) over time to estimate the models. We specify the model in two general ways: (1) the unit of observation is the ZIP code level, and (2) the unit of observation is the recruiting station. In the first specification, the dependent variable is the number of high quality male enlistment contracts obtained from a ZIP code in a given quarter. This number will generally be small, and often zero. Hence, log-log formulations are problematic. Our specification of the ZIP code model is as a "level" model, with non-linearity introduced through quadratic and interaction terms. We attempt to specify the model to be flexible, with

quadratic and interaction terms for the two key variables--recruiters and an indicator variable for whether there is a recruiting station in the ZIP code.

The effect of the recruiting station's location on enlistments is measured in two ways. First, a dummy variable indicating whether the Service has a recruiting station located in the ZIP code is included, along with interactions that allow the effect of the recruiting station to vary with the characteristics of its location. In addition, recruiter productivity is allowed to vary based on the existence of a station in the ZIP code. Second, the distance between the centroid of the ZIP code and the recruiting station to which it is assigned is included in the model. This model is estimated separately for the Army and Navy using ordinary least squares.

We first present results for the ZIP code level models and then the station models, for both the Army and the Navy. ZIP code models for the Army are presented in Table 1. The last column (labeled "Implied elasticity") reports elasticities, at the means, for some key continuous variables. Interactions are included in the elasticity calculations.

**Table 1**  
**Army Zip Code Production Model**

Variable	Parameter Estimate	Std. Error	T-Stat	Implied Elasticity
Intercept	-0.166804	0.02756	-6.052	
Army Recruiters	0.409976	0.02140	19.160	0.4190
Navy Recruiters	0.029811	0.01111	2.682	0.0228
Army Recruiters Squared	-0.000022803	0.00080	-0.028	
Navy Recruiters Squared	-0.005061	0.00114	-4.421	
Army Station in Zip	0.357391	0.10476	3.412	0.2614
Navy Station in Zip	0.420295	0.02425	17.332	
Collocated Station	-0.183598	0.03276	-5.604	
Pop 17-21	0.000113	0.00001	9.757	
Area (sq. miles)	0.000015162	0.00001	1.834	
Pop. Density	-0.000229	0.00001	-17.769	
Distance to Army Station	-0.000294	0.00008	-3.904	-0.0287
Distance to Navy Station	-0.000063306	0.00006	-1.060	-0.0070
Per Capita Income	-0.000005085	0.00000	-8.023	-0.1524
Unemployment Rate	1.033297	0.12960	7.973	0.1378
Urban	0.37079	0.01061	34.944	
Suburban	0.286619	0.01127	25.440	
One High School	0.041416	0.00653	6.340	
Two or More High Schools	0.343885	0.01190	28.887	
R <sup>2</sup>	.275			
Mean of dependent Var.	.404			
Sample Size	234,741			

Note: Model include: dummies for quarter and fiscal year and interaction terms between recruiters and all demographic variables and between stations and all demographic variables.

The "own" recruiter effect implies an elasticity of about 0.42, which is consistent with elasticities in prior studies. Note that Army recruiters are more productive in ZIP codes with high schools, but apparently are not more productive, at the margin, in ZIP codes with recruiting stations. The effect of Navy recruiters on Army enlistments is small, but positive and statistically significant. Taken literally, a 10% increase in Navy recruiters will result in a 0.3% increase in Army male high quality enlistments, suggesting some complementarity. An Army recruiting station in a ZIP code is worth about 0.26 high quality male enlistments per quarter in that ZIP code. (This calculation includes all interaction effects). However, a Navy station in the ZIP code adds about 0.45 additional high quality Army recruits. This result is counterintuitive and may be due to omitted variable bias.<sup>1</sup> If there are both Army and Navy stations in the ZIP the net effect is 0.18, which is less than the sum of the two independent effects, but greater than for each individually. This provides some support for a policy that encourages collocation of recruiting stations.

Distance from each ZIP code to its assigned Army recruiting station has a negative effect on Army enlistments. Interpreted literally, a 10% increase in the average distance between the centroid of the ZIP code and its assigned recruiting station results in about a 0.3% decline in enlistments. The effect of distance from a Navy recruiting station on Army enlistments is not statistically significant. All else equal, ZIP codes with higher per capita income are associated with lower enlistments. The elasticity is -0.15. The unemployment rate elasticity is about 0.14, which is somewhat lower than is typically found in the literature (using district data).

The results for the ZIP code level Navy model are shown in Table 2. The effect of Navy recruiters on Navy enlistments, including the interaction effects, implies an elasticity of about 0.23. This is lower than generally is found in the literature, but is consistent with the 0.3 elasticity found in a recent study of Navy recruiting by Hogan, Dall and Mackin (1996). Navy recruiters are more productive in areas where there is a Navy recruiting station and where there are high schools, according to these results. Army recruiters have a positive effect on Navy enlistments, also suggesting complementarity. Though the elasticity is only slightly less than that for Navy recruiters, the marginal effect of an Army recruiter on Navy enlistments is about half of the effect of a Navy recruiter on Navy enlistments.

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<sup>1</sup> When we estimate essentially the same model, but without interaction effects, we do obtain a larger effect for the Army station on Army enlistments than for the Navy station on Army enlistments.

**Table 2**  
**Navy Zip Code Production Model**

Variable	Parameter Estimate	Std. Error	T-Stat	Implied Elasticity
Intercept	0.040472	0.0199	2.038	
Army Recruiters	0.111906	0.0065	17.322	0.2185
Navy Recruiters	0.262039	0.0269	9.731	0.2277
Army Recruiters Squared	-0.003616	0.0005	-7.841	
Navy Recruiters Squared	0.003279	0.0011	2.912	
Army Station in Zip	0.205186	0.0136	15.101	
Navy Station in Zip	0.57453	0.2176	2.641	0.4266
Collocated Station	-0.037247	0.0255	-1.458	
Pop 17-21	0.000086188	0.0000	9.541	
Area (sq. miles)	0.000002265	0.0000	0.353	
Pop. Density	-0.000159	0.0000	-15.543	
Distance to Army Station	-0.000217	0.0001	-3.746	-0.0312
Distance to Navy Station	-0.000069	0.0000	-1.476	-0.0113
Per Capita Income	-0.000001791	0.0000	-3.677	-0.0792
Unemployment Rate	0.534403	0.0978	5.464	0.1052
Urban	0.282241	0.0081	34.661	
Suburban	0.171679	0.0084	20.383	
One High School	0.036677	0.0050	7.293	
Two or More High Schools	0.221167	0.0092	24.040	
R <sup>2</sup>	.202			
Mean of dependent Var.	.285			
Sample Size	148,093			

Note: Model include: dummies for quarter and fiscal year and interaction terms between recruiters and all demographic variables and between stations and all demographic variables.

The effect of a Navy recruiting station in a ZIP code on Navy enlistments is substantial. Taken literally, the presence of a station increases high quality male contracts by almost 0.43 per quarter. An Army station in the ZIP code results in about 0.2 additional high quality Navy recruits per quarter. Increased distances from the centroid of the ZIP code to both Navy and Army stations have negative effects on Navy enlistments, though the larger effect for the Army distance suggests, again, omitted variable bias rather than a causal factor. Areas with greater per capita income are associated with lower Navy enlistments, all else being equal. The measured elasticity is small, about -0.08. The unemployment elasticity is also a modest -0.10.

In summary, enlistment supply models were estimated for the Army and the Navy at the ZIP code level and at the recruiting station level. The analysis focuses on the effects of recruiters and recruiting stations on enlistment supply, and the factors that affect the productivity of these resources at the local level. In general, we estimate own-Service recruiting elasticities that are generally consistent with the literature. Our estimates indicate that other-Service recruiters do not have a large, negative effect on a given Service's success. There is relatively robust econometric



evidence that Army recruiters have a positive effect on Navy enlistments. There is also evidence that Navy recruiters have a positive influence on Army enlistments, though it is less robust.

Each Service's own recruiting station appears to have a positive and statistically significant effect on the Service's enlistments in the ZIP code in which they are located. In the case of the Army, we tested whether these measured effects may be due to omitted variable bias or endogeneity of the recruit station location choice. The result--a positive and statistically significant effect-- is robust to estimation using fixed effects. For both the Army and the Navy, distance from the recruiting station appears to have a negative effect on enlistments.

The results reported here provide solid evidence of the importance of both recruiters and recruiting stations on enlistment supply. Moreover, they suggest that other Service recruiters have either neutral or positive effects on enlistments. However, the point estimates of effects vary significantly with the specification.

### **Other-Service Models**

The production model relies on the Army-Navy models detailed in the sections above. There are several reasons why we currently focus on these results. For one thing, the Army and the Navy together account for about two-thirds of all annual DOD enlistments. They also absorb a disproportionate share of all DOD recruiting resources. Thus, from a DOD perspective, obtaining reliable models for these two services is a necessary condition for the model. A second reason is that the other services did not provide extensive data on the geographic location of recruiters and stations. The Air Force provided data on station locations and market identifiers for 1998 only, and the Marine Corps was not able to provide any station location or market identifiers. For the Marine Corps we constructed this data based on information on sub-stations available in the Recruiting Facilities Management Information System (RFMIS) for 1998. USMC market territories were constructed using an algorithm that assigned the nearest ZIP codes (in linear distance) to each sub-station. The assumptions that support this assignment process are reasonable but somewhat arbitrary and may introduce some measurement error in the basic variables in the production model.

We consider the results obtained from the Navy-Army data and models to be more reliable than the models estimated with only a single cross-section of data. Nonetheless, for comparison purposes we present results from the estimated Air Force production model in Table 3. The specification of the Air Force production model assumes that Air Force enlistments depend on the number of Army and Navy recruiters in the market area, but not on the number of Marine Corps recruiters. The same assumption is applied to a model of Marine Corps production. The results of the Air Force model are presented in Table 3, while the Marine Corps model is presented in Table 4.

**Table 3**  
**Air Force Zip Code Production Model**

Variable	Parameter Estimate	Std. Error	T-Stat
Intercept	.9939	.0435	22.81
A.F. Recruiters	4.3406	.2035	21.32
A.F. Recruiters Squared	-2.5256	.1059	23.83
Army Recruiters	.4420	.0997	4.43
Navy Recruiters	1.2869	.1500	8.57
A.F. Station in Zip	.4832	.1613	22.99
Army Station in Zip	.4908	.0684	7.16
Navy Station in Zip	-.2142	.0920	2.32
Two collocated Services	-.1580	.1385	1.14
Three collocated Services	-.2103	.1212	1.73
Pop 17-21	.0023	.0001	15.75
Area (sq. miles)	.00003	.00002	1.34
Density	-.0011	.0001	6.69
Distance to A.F. Station	-.0094	.0023	3.92
Distance to Army Station	-.0005	.0002	1.81
Distance to Navy Station	-.0005	.0002	2.34
Per Capita Income	-.00002	.000001	11.61
Urban	.3236	.0380	8.35
Rural	-.4925	.0317	15.50
One High School	.0591	.0226	2.61
Two or More High Schools	.0591	.0456	1.29
R <sup>2</sup>	.345		
Mean of dependent Var.	.920		
Sample Size	24,283		



**Table 4**  
**Marine Corps Zip Code Production Model**

Variable	Parameter Estimate	Std. Error	T-Statistic
Intercept	1.0082	.0565	17.82
M.C. Recruiters	3.0839	.1917	16.08
M.C. Recruiters Squared	-1.1200	.0638	17.54
Army Recruiters	.2788	.1337	2.08
Navy Recruiters	1.016	.1898	5.35
M.C. Station in Zip	.1464	.3272	0.44
Army Station in Zip	.5500	.0911	6.03
Navy Station in Zip	.2364	.1140	2.07
Two collocated Services	.5833	.3025	1.92
Three collocated Services	-.4325	.2301	1.88
Pop 17-21	.0234	.0005	46.39
Area (sq. miles)	.00009	.00005	1.76
Density	-.0012	.0001	11.89
Distance to M.C. Station	.00006	.0004	0.14
Distance to Army Station	-.0014	.0005	2.78
Distance to Navy Station	-.0008	.0003	2.54
Per Capita Income	-.00001	.000002	6.45
Urban	.5347	.0501	10.65
Rural	-.4715	.0420	11.22
R <sup>2</sup>	.471		
Mean of dependent Var.	1.404		
Sample Size	20,954		

### **III. Estimating the Cost of a Recruiting Station**

The econometric model of enlistment supply predicts the change in the number of high quality recruits that would result from opening (or closing) a recruiting station in a particular Zip code. The cost of adding a recruiting station, or the dollar savings resulting from closing a recruiting station, must also be considered in the determination of the optimal number and location of recruiting stations.

To predict the cost of a recruiting station in a particular ZIP code, we estimate an hedonic cost equation. The hedonic cost equation estimates cost as a function of the characteristics of the recruiting station and the characteristics of the ZIP code in which it will be located. The data for estimating the recruiting station cost equation comes from the Recruit Facility Management Information System (RFMIS) maintained by the Army Corps of Engineers. This database contains information on the cost of a facility by Service, the type of facility, how many and which Services share the facility, and a price index of facility costs by geographic area. The data used in the estimation are from FY 1995, FY 1996 and FY 1997. Data on the characteristics of the Zip code come from the database used in the econometric enlistment supply equation estimates.

The dependent variable is the lease cost at a facility for a Service. Table 5 presents the estimated coefficients of the model:

**Table 5**  
**Recruiting Station Cost Equation**

Variable	Description	Coefficient	t-ratio
Intercept		-2051	-1.3
Recs	Number of recruiters located at the station	1415	80.2
Navy	Dummy variable equal to 1 if the Service is Navy	65.5	0.2
USAF	Dummy variable equal to 1 if the Service is Air Force	-2369	-8.2
USMC	Dummy variable equal to 1 if the Service is USMC	-633	-2.3
Joint 2	Dummy variable equal to 1 if there is one other Service at facility	-958	-2.7
Joint 3	Dummy variable equal to 1 if there are two other Services at facility	-901	-2.7
Joint 4	Dummy variable equal to 1 if there are three other Services at facility	-935	-3.3
Main	Dummy variable equal to 1 if the facility is a main recruiting station	6712	5.6
Intermediate	Dummy variable equal to 1 if the facility is an intermediate recruiting station	-2015	-5.4
Counselor	Dummy variable equal to 1 if counselors are stationed at the facility	32263	4.6
Part time	Dummy variable equal to 1 if the facility is used only part time	-1854	-2.0
Median income	Median per capita income for the Zip code	0.03	2.8
Population Density	Population density in the Zip code	0.125	7.9
Adjustment	Index of facility cost in geographic area of the Zip code	2222	1.9
FY 96	Dummy variable equal to 1 for FY 96 data	320	1.3
FY 97	Dummy variable equal to 1 for FY 97 data	670	2.5
EASTNC	Regional dummy variable for Zips in East North Central states	3083	4.4
ESTSC	Regional dummy variable equal to 1 for Zips in East South Central states	823	1.0
MIDATL	Regional dummy equal to 1 for Zips in mid-Atlantic states	1292	2.5
MOUNTAIN	Regional dummy equal to 1 for Zips in Mountain states	1293	2.0
PACIFIC	Regional dummy equal to 1 for Zips in Pacific states	4817	9.0
SOUTHATL	Regional dummy equal to 1 for Zips in South Atlantic states	1880	2.7
WESTNC	Regional dummy equal to 1 for Zips in West South Central states	2525	3.4
WESTSC	Regional dummy equal to 1 for Zips in West South Central states	1371	1.9
URBAN	Dummy variable equal to 1 for Zips in urban areas	2359	8.8
Rural	Dummy variable equal to 1 for Zips in rural areas	371	0.9
R <sup>2</sup> =0.77	N=10,323		

The "reference group" in the estimating equation is a standard Army recruiting station in the suburbs of the Northeast. The 'dummy' variables are relative to this reference point. The "recruiter" measures the effect of assigning additional recruiters to a facility. Additional recruiters imply more space. Costs, therefore, increase with recruiters assigned through the effect this has on required square feet of space. An additional recruiter adds about \$1,400 per year to the lease cost of a facility, because of the effect on the space that must be rented.

From the equation, we note that Air Force and Marine Corps lease costs for a given facility are typically less than the Army's or Navy's. The Service's cost at a facility that is shared jointly with one or more other Services cost that Service about \$900 less per year than there were single Service occupancy. Facilities in urban areas cost significantly more than facilities in either suburban or rural areas.

The model can be used to estimate the cost of adding a recruiting station in a particular ZIP code simply by inserting the appropriate values for the facility and for the Zip code.

#### **IV. LOCATION OPTIMIZATION**

The econometric and cost models enable us to predict production and cost for a *given* set of stations and allocation of recruiters to those stations. In this section, we describe an optimization model that selects stations and allocates recruiters to maximize production.

Once the user has the ability to view current station locations and recruiter allocations, he can pose a number of questions. For example, he may need to locate a new station in a particular region—where should it go? He may have five new recruiters to distribute among existing stations—where should they be assigned? Or he may wish to re-evaluate the locations of all existing stations—how much production could be achieved if we could move any station?

Each of these decision problems can be formulated as a mathematical program, which seeks to optimize some objective (say, maximize production), subject to resource constraints (budgets, or total number of stations and recruiters, for example). RSLES provides through its interface the ability to formulate many of these scenarios; users with knowledge of the GAMS programming language can solve other problems by modifying the optimization code.

**Optimization Model.** The prototypical problem is the following: Given a set of ZIP codes that define a geographical region and a subset of those ZIP codes that can contain stations, locate recruit stations for multiple services among the candidate ZIP codes and assign recruiters to stations in order to maximize production, subject to budget or other constraints. We formulate the problem as a large, linear mixed integer program. The technical report "GAMS Optimization Procedure" by Martin and Gue gives a detailed description of the model and our solution technique.

**An Overview.** The model makes three basic decisions: it selects station locations for each service from among a set of candidate ZIP codes, it assigns ZIP codes to those stations to form station territories, and it allocates recruiters to each station. The user is able to solve for a single

service, holding stations and recruiters fixed for other services; or he can allow the model to manipulate stations and recruiters for all services.

Due to the size of typical station location problems, we decompose the problem into three sub-problems, each providing input to the following one. We solve the model in three steps: in the first, we locate stations among candidate ZIP codes; in the second, we assign ZIP codes to stations; in the third, we allocate recruiters to stations.

The objective of the model is to maximize production for all services. The user may choose simply to maximize production for one service (the single-service problem), in which case assets for other services remain fixed at current locations, or he may choose to maximize production for all services (the joint problem). In any case, the model is free to collocate stations of one service with stations of other services. We assume that two stations in the same ZIP code are collocated.

It is important to note that, for the joint problem, the model makes no distinction between types of recruits; that is, it considers an Army recruit to be of the same worth as an Air Force recruit, and so on. Because the Air Force typically is more productive per recruiter, one might expect the model to produce a preponderance of Air Force recruits because they are more easily obtained. This turns out not to be the case because we construct resource constraints by service, rather than having an overall DOD resource constraint. For example, the model gives each service a budget to spend, rather than having a single DOD budget. This way, the model is forced to obtain the greatest number of recruits for each service, given the budget for that service.

The primary constraints in the model involve budgets, the number of stations, and the number of recruiters. If the user does not specify a number of stations or recruiters, the model automatically calculates budgets based on the existing configuration of stations and recruiters for each service. It then maximizes production subject to these budget constraints. Notice that the model is free to trade off stations for recruiters and vice versa based on obtaining the highest possible production; this, in fact, is one of the main benefits of the model.

The user may also specify a particular number of stations and recruiters. For example, he may constrain the model to locate 12 stations and assign 46 recruiters for the Army, and so on for the other services. The user may also fix any of the existing stations and recruiters. For example, suppose the user is happy with 10 of 12 existing stations, but is considering relocating the other two. He can fix the locations of the 10 and allow the model to close, relocate, or keep open the remaining two.

Depending on how the user sets up the model, it may return an optimal or infeasible solution. For example, if we specify that the solution must have at least 12 stations and 40 recruiters for the Navy, and the Navy budget is too small to support this minimum configuration, the problem is infeasible.

**Problem Size Issues.** Integer programs are among the most difficult computational problems known to researchers. Naturally, *large* integer programs are even more difficult. To

work around these realities, we do not consider every ZIP code in a region as a possible site for a station. Instead, the user must specify a subset of candidate ZIP codes; the larger the subset, the longer it will take for the problem to run, and the greater the possibility that the problem will not solve at all.

Currently, we are able to solve problems with as many as 300-400 ZIP codes and 65 candidate station ZIP codes. This covers all defined metro areas in the U.S., except metropolitan Los Angeles and New York. Almost all problems of the size of a Navy District, Army Battalion, or Air Force Squadron are beyond the capabilities of the model. Further research is needed to handle problems of this size.

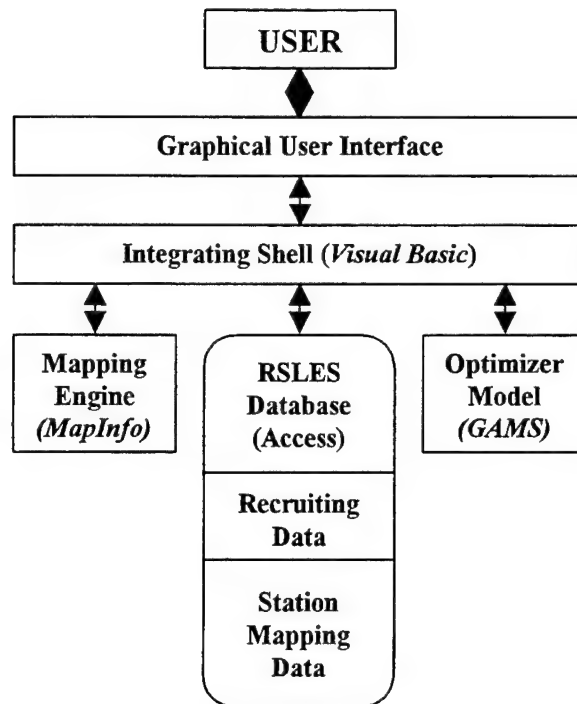
Selecting candidate ZIP codes is important because the model can only choose from among them to location stations. RSLES provides a productivity index for each ZIP code in a geographical area to help the user determine which ZIP codes would make the best candidates. The index is simply that portion of the

**Validation.** To test the model, we analyzed Army and Navy stations in 39 metropolitan areas, ranging in size from 13 ZIP codes to 354 ZIP codes. In our first test, we seek to validate the predictive capability of the model. We recorded historical production for each of the 39 metro areas (the production average for the previous three years) and compared those figures with output from the model, given the current configuration of stations and recruiters. In these runs, the model is not making any location or allocation decisions, because they are fixed; the model only constructs territories and computes predicted production. The model appears to have good predictive capability, as demonstrated by an  $R^2 = 0.90$ . We also note that roughly the same number of predictions is below actual as above it.

In a second test, we examined recent station location actions by Navy recruiting districts. In almost every case, the Navy had recently opened one or more stations. We took a retrospective look at those decisions and posed the question, "Could they have done better with the model, and if so, by how much?" These results are discussed fully below in Section VI.

## **V. RLSES Decision Support Software**

It became clear early in the project that budget and time limitations would not allow the development of an application that would carry out all functions of this project independently. This led to the integration of several commercial off-the-shelf (COTS) products to conduct the optimization and assist in the GIS portion of the project. As shown in Figure 1, the RSLES application architecture consists of four components: an integrating shell, a mapping engine, an optimizer model, and a database management system.



**Figure 1. RSLES System Architecture**

At the heart of the RSLES architecture is an optimizer model that was developed to minimize recruiting costs subject to production requirements. The optimizer model chooses from among a list of candidate ZIP codes within a defined geographical area and identifies which ones should contain recruiting stations as well as the optimal number of recruiters associated with each station. This information is then mapped to operational source databases and graphically displayed. The database contains the source data necessary for the mapping process and for the optimizer model to run.

**Integrating Shell.** The application shell that integrates the COTS products and operates the GUI is original code written in Visual Basic. Visual Basic is an event-driven programming language that has many object-oriented features and is excellent as a RAD tool for developing integrated applications. In the event-driven model, programs are no longer procedural, and they do not follow a sequential logic (Bradley, 1998). Rather, the user determines the sequence of execution dynamically. An additional benefit of using Visual Basic is that several primary users, such as USAREC, already have information system support personnel with Visual Basic programming experience. This provides an opportunity for future prototype maintenance and improvements to be completed in house by those experienced programmers.

Another requirement for the prototype was that the final application should relieve the user from the burden of understanding the individual COTS applications and protocols involved in the transfer of information. Because of the limited and structured nature of the decision process used to determine Recruit Station location, automation of most of the tasks was necessary. This included passing data to the optimizer, geocoding, and creating thematic maps for the visual display of metrics associated with individual recruit stations. The only exception to this

requirement in RSLES is that the user must be somewhat familiar with the basic toolbar functions of MapInfo such as select, zoom-in, zoom-out, and layer control.

Required inputs from the user are minimal and include proposed ZIP codes where a station should be opened, where a station should be closed, or 'candidate' ZIP codes where the user allows the optimizer model to consider specified ZIP codes for closing or opening. Appendix B (User Interface Final Layout) shows the RSLES User Interface screens used to capture the input parameters.

The GUI accepts these inputs and then uses them in an SQL query to identify the characteristics associated with each ZIP code (i.e. total high schools, population density, etc.) where a station is currently located. This information is then combined with the domain's (i.e. Battalion, District, or Metropolitan area) characteristics and is then used to create GAMS input files in Visual Basic (GAMS Source File listing is provided in Appendix Q. The input files are then passed into the optimizer using a shell. These tasks are carried out through Object Linking and Embedding (OLE) automation with the mapping engine. Others are carried out using the database engine in Visual Basic. Automation (formerly OLE Automation) is an industry standard used by applications that allows objects to be shared by many applications.

**Mapping Engine.** MapInfo was chosen as the mapping engine for several reasons. MapInfo satisfied all the known and anticipated functional requirements, is well supported and documented, and minimizes the need for additional training, since it is already in use at each Service's Recruiting Commands. Additionally, version 5.0 of MapInfo allows Visual Basic to use MapInfo tables as bound data control objects. It also allows for direct export of data tables to Microsoft Access and other database applications.

MapInfo is a commercial mapping package that serves as a graphical input tool and a mechanism for the spatial definition and processing of data. It converts positions to distances, makes proximity determinations, and classifies objects by geographical region. The integrating shell uses an automation object to pass data to and from MapInfo and to execute queries in MapInfo. The ability of MapInfo to localize data from huge databases provides a significant performance gain when certain queries are implemented. Finally, MapInfo is the GIS currently in use by the military recruiting commands.

**Optimizer Model.** The optimizer model for the RSLES application was developed using GAMS. GAMS was specified by OSD for implementation because of its powerful solver capabilities and its ability to provide a flexible decision analysis environment. The optimizer model has the primary objective of minimizing DoD cost subject to a target production goal. Another optimization model was developed (Martin, 1999) that has the primary objective of maximizing the number of contracts from a region subject to a budget constraint (Max-Production model). Due to time constraints, RSLES only incorporates the default model, which is the Minimum-Cost model (referred to as "MinCost" model).



GAMS presents several obstacles to communicating with other applications, primarily because it is a DOS-based application. Fortunately, Visual Basic provides a 'shell' function, which allows the ability to interface with DOS-based applications. The RSLES application must pass control to GAMS in order to run the optimizer. This requires that text files be created to include the data positioned in the format required by the Min-Cost model. In total, seven files are required as input to the Min-Cost Model (Appendix Q). The files include data regarding the domain of ZIP codes, attributes of each ZIP code in the domain, units selected, ZIP codes where stations should be closed, opened, or ZIP codes where a station can be "considered" for opening or closing. Some of the files contain attribute data about the domain being optimized (i.e. battalion, district, company, or zone) while others contain attribute data for only the ZIP codes under consideration. While cumbersome, this proved to be the only method to pass the required data to GAMS.

Another limitation is the maximum size of the problem the Min-Cost model is capable of considering. Although it would be beneficial for planners to be able to optimize RS locations for district/battalion sized areas, problems of this size are computationally intractable. The current Min-Cost model solves problems at the company/zone level (for single-service scenarios) and the metropolitan area level (for joint scenarios).

Fortunately, displaying Min-Cost model output was less of a challenge. The optimizer model output is in a text-based format, allowing the RSLES shell to pass the file to MapInfo for evaluation and geographic display. This required several steps, including geo-coding the necessary tables. While this functionality is built into the MapInfo application, we preferred to automate the process for the user, thereby saving a significant amount of time anytime the process was necessary. However, from a coding standpoint, this process proved extremely difficult because the MapX program was not available for use. Ultimately, we were able to automate the geo-coding process, which proved to be the most difficult module to develop during the coding process.

**Database Management System.** The final component of the architecture is the database management system (DBMS) for which we selected Microsoft Access 97. There were many reasons for its selection, however the overriding factor is its ready availability to the end users who will be using RSLES. When considering the necessary tools for managing databases on Windows-based PCs, the benefits of Access 97 best fit the requirements. For example, it is a true 32-bit DBMS with a multi-threaded, 32-bit database engine (the Jet 3.5 engine). The Jet Engine is a well-designed relational database engine and is shared across Microsoft products, most notably Visual Basic. It is also very extensible, including support for 32-bit OLE custom controls, the Windows 32 API, and VBA add-ins (Litwin, 1996). Also important is the fact that it has an excellent object model for the manipulation of data using Visual Basic code: Data Access Objects (DAO). This, combined with its support for SQL and dynasets, which are a temporary set of data taken from one or more tables in an underlying file, made it the most sensible choice for this project.

Initially, an attempt was made to rely solely upon MapInfo's DBMS to remove one less object from the architecture. While the properties of data bound controls could be set to MapInfo tables, we were unsuccessful in integrating the two applications in other areas where



MapInfo-specific code (MapBasic code) was required. Although it may be possible, and perhaps even more efficient, time constraints prevented such an implementation. Additionally, the inconsistency of source databases as well as their numbers and sizes, would have posed considerable implementation challenges for such a design interface.

The RSLES architecture has the major benefit of already having the necessary infrastructure in place at many commands that will be using RSLES. The choice to use a hybrid solution, combining various COTS components, was necessary because no one COTS product exists that satisfies all of the requirements. However, by using several applications that can be nearly seamlessly integrated to provide a total solution, the likelihood of meeting all requirements can be increased. The disadvantages are that broader product knowledge is required during development and the mechanics of package integration often proves difficult, particularly with respect to data transfer between applications. Additionally, open database connectivity, object linking and embedding, dynamic link libraries, and other integration tools necessary for multiple COTS applications add a layer of complexity that can adversely affect performance and reliability. Finally, version maintenance of the COTS products, once the system is deployed, becomes the counterpart of the traditional software maintenance problem. The configuration of new versions as they become available can consume substantial amounts of time as the system evolves.

The DSS architecture of an optimizer model, mapping engine, database management system, and an integrating application system provides the necessary tools for recruit station location decision support. Combining these components provides process functionality that previously did not exist.

## **VI. Model Assessment and Applications**

Our goal was to apply the RSLES model to a representative sample of the 256 metropolitan areas in the U.S. Thus, we applied the model to 39 metropolitan areas (MSA's) of various sizes where station openings were planned for FY99 and FY00 by the Army and Navy. We first collected actual station location data from CNRC and USAREC. This data included proposed new station locations and expansions by zip code and the number of recruiters to be assigned to each new recruiting station.

### **Three Alternative Scenarios for Model Application**

**The "New Recruiter Optimization" Scenario.** The New Recruiter Optimization scenario adopts the actual station alignment (as of 1998) and then adds recruiters based on CNRC decisions in 1999 and 2000. RSLES chooses where to locate the additional recruiters to achieve maximum production given the budget and CNRC/USAREC station manning constraints. The model determines the allowable budget based on the number of allocated recruiters and new stations that were opened in the MSA. It then optimizes station location from the list of candidate zip codes. The goal of this scenario is to test whether it can be used to assist decision-makers' location selections when opening new stations. This model allows us to compare

CNRC/USAREC actions in regards to station location versus recommendations from the optimization procedure in RSLES.

**'Baseline' Scenario.** The second model application is based on CNRC/USAREC decisions made by district or battalion commanders to modify station alignment by opening, closing and expanding stations. This model is used to find the estimated production within the given MSA as per actual station alignment decisions made by CNRC/USAREC. This application allows us to compare predicted production from the New Recruiter Optimization Scenario with the production predicted from the actual CNRC/USAREC decision.

**'Full RSLES Optimization' Scenario.** The final application was to allow RSLES free reign in optimizing station location within the entire MSA. In this scenario, the model is allowed to optimize station alignment and new resources without imposing any restrictions on current station locations. This scenario allowed us to compare estimated production from the CNRC/USAREC decision scenario (the second scenario) with estimated production from an optimal MSA station location scenario.

The RSLES model was applied to 39 MSA's that vary in size from Chicago (population= 488,520) to Wasau, Wisconsin's (population = 9,340). Chicago MSA also has the most zip codes with 354 and Monroe, Louisiana has the least with 13. The 39 MSA's were located in 11 of the 31 Navy Recruiting Districts. Table 5 displays the demographics of the selected MSA's for the Navy.

**Table 5. Demographic Characteristics of Selected MSA's**

<b>MSA</b>	<b>Region</b>	<b>Population</b>	<b>Population Category</b>	<b># of Zips in MSA</b>	<b># of Candidate Zips</b>
Atlanta	S	156492	L	135	35
Greenville	S	56473	M	63	25
Columbia	S	38457	S	32	19
Charleston	S	33105	S	42	14
Augusta	S	28980	S	37	13
Syracuse	N	55418	M	112	26
Buffalo	N	72789	M	85	25
Albany	N	59093	M	137	25
Rochester	N	69328	M	123	32
Utica	N	19922	S	63	14
Chicago	C	488520	L	354	65
Oklahoma City	C	70314	M	95	24
Denver	W	135444	L	129	30
Orlando	S	88896	M	92	30
Jacksonville	S	54788	M	52	25
Melbourne	S	22503	S	29	19
Minneapolis	C	159232	L	215	50
Milwaukee	C	93609	M	96	31
Appleton	C	25744	S	36	9
Madison	C	34992	S	45	21
Wausau	C	9340	S	22	22
Nashville	S	64400	M	104	25
Louisville	S	60960	M	83	26
Chattanooga	S	24527	S	44	23
Knoxville	S	38287	S	66	24
Lexington	S	33655	S	36	18
New Orleans	S	79717	M	77	30
Monroe	S	11292	S	13	13
Shreveport	S	22641	S	42	19
Baton Rouge	S	35688	S	37	21
Little Rock	S	33120	S	52	24
Las Vegas	W	54259	M	51	25
San Francisco	W	380998	L	290	62
Sacramento	W	102341	L	119	30
Modesto	W	27419	S	26	26
Stockton	W	31455	S	29	29
Visalia	W	19750	S	34	34
Salinas	W	27255	S	28	28
Fresno	W	45784	S	64	24

0 - 50K	S
50 - 100K	M
100K or more	L

**Regions**

North	N
South	S
Central	C
West	W

## **Assessment and Validation of RSLES**

The validation process verifies the predicted production from the RSLES model with actual historic production, based on the average of DOD high quality male accessions from every populated zip code within a MSA during fiscal years 1995 - 1997. The data collected is used to determine the ability of RSLES to achieve its objectives. We compare the historical production of the 39 MSA's to the estimated production obtained from RSLES. Secondly, we review the differences between recruiting station location recommendations made by RSLES versus actual choices made by CNRC/USAREC decision makers.

## **Navy Station and Recruiter Alignment Comparisons**

To review production potential for Navy recruiting we applied three different scenarios to RSLES. The 'Baseline' scenario applies RSLES to a set of candidate zip codes that represent the original station alignment (prior to 1999) and to zip codes where CNRC planned to open stations in 1999 and 2000. The 'New Recruiter Optimization' scenario applies RSLES to the original station configuration (prior to 1999) and includes the additional recruiters assigned to each MSA by the Army and Navy in 1999 and 2000. That is, the RSLES model is asked to distribute the new recruiters to the existing stations. The 'Full Optimization' scenario allows RSLES to recommend station alignment with no existing alignment mandated or other constraints except that each station must contain at least two recruiters. Table 6 shows the estimated Navy high-quality contract production by MSA under the three scenarios.

For the 39 MSAs that were analyzed, The New Recruiter Optimization scenario (column 2 in Table 6) increases the number of high-quality male accessions by 59 compared to the Baseline scenario based on STEAM data (column 1 in Table 6). This represents an increase in production of 1.59%. If we extrapolate this percentage improvement to all MSA's in the U.S., we could expect 387 additional high quality accessions per year if new stations were opened under RSLES guidance as compared to STEAM.

However, in the Full Optimization scenario, RSLES predicts an increase of 218 high quality accessions in the 39 MSA sample. This represents an increase in production of 5.64% over the Service-Decision scenario. Extrapolating this percentage difference to all MSA's would imply 1,431 additional high quality accessions per year. Production increases of this magnitude could significantly reduce current annual Navy recruiting shortfalls. However, consideration must be given to the costs of wholesale station changes such as disruption of local recruiter practices and subsequent production decreases in the short term. In our sample alone, to maximize production with the optimal station alignment, CNRC would have to close 105 existing stations and open 229 in new locations. The 105 closings represent 52.5% of the original 221 stations. The Full Optimization scenario would call for 345 recruiting stations of which the 229 required openings consist of 66.4% of the total. An interesting result is that of the 779 recruiters, 540 of them (69.3 percent) would have to be relocated, 485 recruiters would need to change station locations and 55 recruiters would no longer be required.

**Table 6****Navy High-Quality Contract  
Production for Three  
Scenarios**

<b>MSA</b>	<b>Baseline Scenario</b>	<b>New Recruiter Optimization Scenario</b>	<b>Full Optimization Scenario</b>
Atlanta	189	189	203
Greenville	57	57	61
Columbia	49	49	51
Charleston	54	52	56
Augusta	40	39	42
Syracuse	52	52	59
Buffalo	83	83	84
Albany	25	25	29
Rochester	37	37	46
Utica	10	10	10
Chicago	587	646	656
Oklahoma City	211	208	215
Denver	217	215	224
Orlando	157	158	162
Jacksonville	100	100	105
Melbourne	53	51	52
Minneapolis	92	93	103
Milwaukee	128	129	135
Appleton	33	33	34
Madison	29	29	31
Wausau	18	18	18
Nashville	53	55	62
Louisville	49	51	53
Chattanooga	27	27	30
Knoxville	37	37	42
Lexington	34	34	38
New Orleans	173	174	180
Monroe	32	32	34
Shreveport	63	63	66
Baton Rouge	63	64	66
Little Rock	79	79	83
Las Vegas	114	112	120
San Francisco	385	377	379
Sacramento	124	125	127
Modesto	46	46	49
Stockton	45	52	51
Visalia	30	30	32
Salinas	19	20	23
Fresno	50	52	51
<b>Total</b>	<b>3644</b>	<b>3703</b>	<b>3862</b>

The required station actions to achieve the maximum production are shown in Table 7 for one Navy Recruiting District -- NRD-Buffalo. Each MSA in which NRD Buffalo made station changes during fiscal years 1999 or 2000 is listed in its own section of Table 7. The zip codes listed are those in the MSA affected by the Full Optimization scenario. The Baseline scenario RAF (Recruiter Assignment Factor) represents the number of recruiters stationed in that zip code. The "open/close" column is blank when the station location remains unchanged, while the open or close label refer to the station action required to maximize production in the Full Optimization scenario. In the case of Syracuse, zip codes 13045 and 13021 have 2 recruiters assigned and RSLES recommends they stay there. Stations in zip codes 13211 and 13126 are recommended for closure and zip codes 13421, 13029, 13204 and 13205 are recommended for station openings with 2 recruiters in each station.

**Table 7. Recommendations for NRD Buffalo in Two Scenarios**

	Zip Code	Baseline Scenario RAF	Open/ Close	Full Optimization Scenario RAF
<b><u>Syracuse</u></b>	13045	2		2
	13021	2		2
	13211	4	Close	
	13126	3	Close	
	13421		Open	2
	13036		Open	2
	13205		Open	2
<b><u>Rochester</u></b>	14020	2		2
	14424		Open	2
	14513		Open	2
	14456	5		2
	14615	4	Close	
	14623	6		2
	14437		Open	2
	14420		Open	2
	14609		Open	2
<b><u>Buffalo</u></b>	14225	5		2
	14203	2	Close	
	14075	4		3
	14094	4		2
	14150	4		2
	14221		Open	2
	14120		Open	2

	14304		Open	2
	14223		Open	2
<b>Utica</b>	13421		Open	2
	13440	2	Close	
	13413	5	Close	
	13316		Open	2
	13501		Open	2
<b>Albany</b>	12866	2		2
	12010		Open	2
	12205	4	Close	
	12305	3	Close	
	12180	4		2
	12208		Open	3
	12309		Open	2
	12095		Open	2

### Army Station and Recruiter Alignment Comparisons

The same scenarios discussed above were also applied to the Army. For the 39 MSA sample, the RSLES Basic scenario increases the number of high-quality male accessions by 93 compared to USAREC decisions made using ATAS. This represents an increase in production of 1.46%. If we extrapolate this percentage improvement to all MSA's in the U.S., we could expect 612 more high quality accessions per year if new stations were opened under RSLES guidance as compared to ATAS. However, in the Full Optimization scenario, RSLES predicts an increase of 381 high quality accessions in the 39 MSA's. This represents an increase in production of 5.72% over the Baseline scenario. This percentage increase is consistent with production improvement estimates for the Navy. Extrapolating this percentage difference to the entire U.S. yields 2,507 additional high quality accessions per year. Production increases of this magnitude could eliminate a significant portion of the Army's annual recruiting shortfalls.

## **VII. Conclusions**

The original GAO and Congressional mandates to OSD involved two major objectives: 1) Conduct cost-benefit analyses in all decisions about maintaining or establishing new recruiting stations; and 2) Evaluate the benefits and costs of keeping stations open in less productive areas. As a result, OSD set performance criteria for any model that would be used to determine the optimal number and geographic location of recruiting stations. Those criteria were:

- 1) The model must integrate effects of geographic location and station structure on station costs, contract production and station territory;
- 2) The model must develop empirical relationships using statistical methods and objective data;
- 3) The model must use principles of resource allocation efficiency that meet services' recruiting objectives but within JRFC resource constraints;
- 4) The model must capture the institutional aspects associated with choosing the number, type and location of recruiting stations; and
- 5) The model must build on existing literature.

The RSLES model meets these criteria. First, RSLES integrates the effects of geographic location on station costs by developing an empirical model to estimate how much local area demographic characteristics affect station costs. Second, an econometric model determines the effects of specific geographic locations – at the ZIP code level -- on production. The effects of geographic location on station territory are incorporated into the optimization model. The RSLES model integrates the econometric model, the cost model and the optimization software to provide station allocation recommendations at the metropolitan area (MSA) level.

The optimization routine locates stations in ZIP codes so as to maximize production subject to a budget constraint. The model was applied to real-world station stationing and recruiter assignment actions made by the Navy Recruiting Command in fiscal year 1999 and 2000. This application found that if the RLSES model had instead been used to identify the locations for the new stations, improvements in production of as much as 15 percent would have been achieved, compared to the baseline situation. However, these gains were confined to specific metropolitan areas. This suggests that one use of RSLES is to identify geographic areas (Districts, metro areas) in which changes in station location and recruiter alignment would yield the greatest improvements in production. A second application of the RSLES software was at the annual JRFC Collocation Conference in which specific stationing actions were analyzed to determine whether location changes requested by the individual Services were supported by the model. The model is particularly valuable in determining whether single-service stations make sense or whether collocation should be preserved.



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